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STUDIES OF MAPLE SAP

BY FRED W. MORSE

NEW HAMPSHIRE COLLEGE

OF

AGRICULTURE AND THE MECHANIC ARTS

DURHAM, N. H.

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MAPLE SAP STUDIES

BY FRED W. MORSE

The studies of maple-sap, begun three years ago by Professor Wood and myself, were continued this season with the assistance of Mr. Edward P. Stone.

The time which could be given to the work this year was devoted to the consideration of two problems, viz., the variation in composition and flow of sap during the season, and the differences in sap from the outer and inner layers of wood. The experiments were confined to five sugar maples (*Acer saccharinum*) because it was impracticable to handle any more samples of sap than these five involved. The trees were designated respectively by the numbers, 5, 8, 10, 11 and 12.

Numbers 8 and 11 were tapped in the usual manner followed by sugar-makers, by boring in the south side of the trunk about three feet from the ground, a hole two inches deep and three-eighths of an inch in diameter. Eureka spouts were inserted in the holes and the sap was collected in covered tin buckets.

The trees were situated about ten rods apart on opposite sides of a highway running east and west. They were nearly the same size with trunks measuring a little less than seven feet in circumference and well developed tops with many branches. Number 8 stood on the south side of the road and number 11 on the north side.

The tapping was done on March 11, but the sap did not flow until March 13. The weather was variable during the entire term of bleeding and there was but one period during which the sap ran freely on successive days. This period was from April 4 to April 7.

The whole season was characterized by blustering winds alternating with rain or snow. The ground was entirely thawed by rains on April 8 and 9, and the flow of sap from these trees

stopped on April 12, at the beginning of another rainy period lasting four days. No precise weather observations were taken because of a lack of suitable instruments, at the time, in the meteorological department.

Such weather, with wind and rain, not only interfered with the regular flow of sap, but on two or three occasions spoiled the samples.

The dates upon which sap was collected and sampled are given in Table 1, together with the weights of sap and percentage of sugar (*saccharose*), and the weights of sugar calculated from them. The relations existing between the results are more plainly shown by the diagram.

The rate of flow was very irregular and in most cases the percentage of sugar fell when the quantity of sap increased and rose when it decreased. The variations in quality were so small, however, that the weights of sugar followed the weights of sap quite regularly. The percentage of sugar gradually fell from the beginning of the season until toward the close, when there was a rise. A similar variation was observed to exist in the results from eleven out of thirteen trees, reported in Bulletin 5 of the Division of Chemistry, U. S. Department of Agriculture.

TABLE I.

Composition and Flow of Sap from Ordinary Holes.

Tree No. 8.

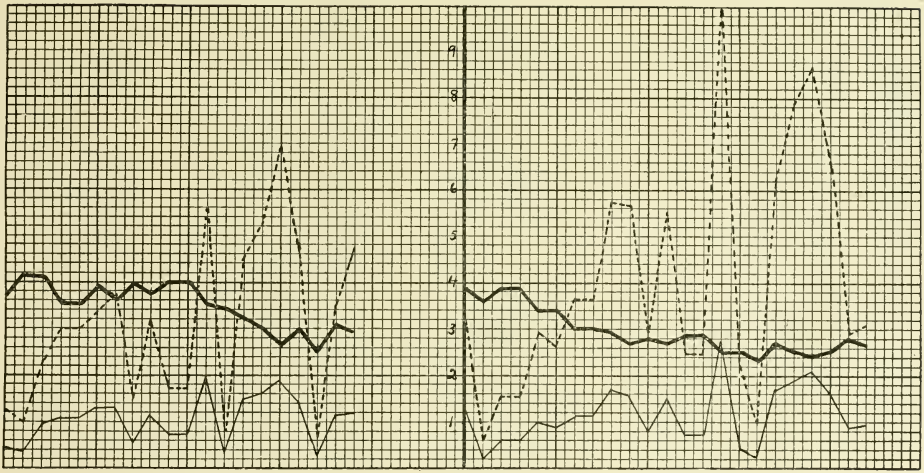
Date.	Grammes Sap.	Per Cent Sugar.	Grammes Sugar.
March 13	1250	3.70	46.2
14	950	4.17	39.6
21	2278	4.14	94.3
23 and 24	6018	3.56	214.2
25	3369	3.92	132.0
27	3704	3.58	132.6
28	1513	3.94	59.6
29	3210	3.73	119.8
30 and 31	3458	3.97	137.3
April 1	5652	3.56	201.2
2	796	3.46	27.5
4	4553	3.33	151.6
5	5289	3.00	158.6
6	6902	2.70	186.3
7	4617	3.00	138.6
9	663	2.50	16.6
11	3645	3.10	113.0
12	4782	2.93	140.2

TABLE I. (CONTINUED.)

TREE NO. 11.

DATE.	GRAMMES SAP.	PER CENT SUGAR.	GRAMMES SUGAR.
March 13	3250	3.90	126.8
14	589	3.62	21.3
19 and 20	3079	3.93	121.0
21	2895	3.46	100.2
22	2609	3.43	89.5
23 and 24	7331	3.00	220.0
25	5725	2.96	169.4
27	5676	2.73	155.0
28	2893	2.83	81.9
29	5550	2.68	148.7
30 and 31	5000	2.86	143.0
April 1	10891	2.50	272.3
2	2255	2.53	57.0
3	949	2.33	22.1
4	6275	2.66	166.9
5	7875	2.53	199.3
6	8780	2.46	216.0
7	6540	2.50	163.5
11	2835	2.80	79.4
12	3098	2.73	84.6

DIAGRAM I.



TREE NUMBER 8.

TREE NUMBER 11.

Kilogrammes of Sap, ...
Percentage of Sugar, ———
Hectogrammes of Sugar, _____

Number 5 was situated on the south side of the road nearly opposite number 11. It had a top of medium size and a trunk measuring three feet and ten inches in circumference.

It was tapped by boring a hole two inches deep with a three-fourths-inch bit and continuing it two inches farther with a half-inch bit. The smaller part of the hole was fitted by means of a rubber stopper with a one-fourth inch tube and the outer part had a half-inch tube similarly arranged. (See Fig. 1.) The smaller tube thus passed through the larger and extended two inches beyond it. By means of a glass funnel and rubber tubing the sap from the two sections or layers was conducted to different bottles.

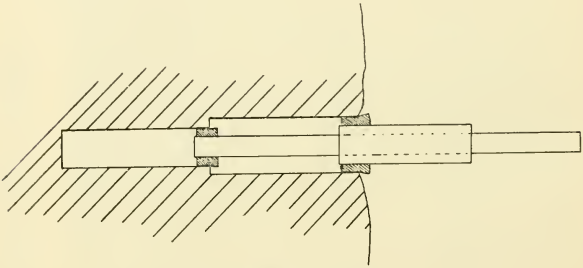


Fig. 1. Insertion of Tubes.

Number 12 was situated at a distance from the highway, at the foot of a wooded knoll and in moist soil. Its trunk measured four feet and eight inches in circumference, and its top was sparingly branched owing to its surroundings of other trees. It stood, however, on the edge of the grove exposed to the south, and consequently it bled more freely on cold, windy days, than any of the others.

It was tapped with a hole three-fourths of an inch in diameter and four inches deep. Two tubes, one inside the other, were fitted into the hole by means of rubber stoppers, which divided the hole into two sections, each two inches in length. The inner tube extended to the inner section and was three-eights of an inch in diameter. The outer tube, which was fitted

to the outer part of the hole, was five-eighths of an inch in diameter. An arrangement of funnel and tubing, like the one employed with number 5, was used for collecting the two lots of sap.

These trees were not tapped until numbers 8 and 11 had begun to flow freely and the sap was not collected during the whole time of bleeding, but the same length of time was always employed for collecting the samples from the two depths in the tree.

The tables and diagrams show that the outer two inches yielded a sap with a higher percentage of sugar (*saccharose*) than was contained in that from the inner two inches. The results on sap-flow were contradictory. Number 5 bled more freely from the outer two inches and number 12 from the inner. Number 5 ceased bleeding on April 12, the date on which 8 and 11 had stopped. Number 12 also stopped on this date; but after the wet weather had ended, there was a succession of frosty nights and warm days and the inner section again began to bleed but not so freely as before the rains, and did not cease until the buds had burst and the leaves had begun to expand.

With both trees, the parts producing the most sap, yielded the most sugar.

The flow of sap from number 12 varied about the same from both inner and outer parts until the day on which the latter ceased bleeding, when the former yielded its maximum quantity.

TABLE II.

FLOW AND COMPOSITION OF SAP FROM THE OUTER AND INNER PARTS OF THE TREE.

TREE No. 5.

DATE OF COLLECTION.	DURATION OF COLLECTION.	GMS. SAP.		PER CENT SUGAR.		GMS. SUGAR.	
		OUTER.	INNER.	OUTER.	INNER.	OUTER.	INNER.
March 27				2.80	1.86		
April 1	9 A. M.–11 A. M.	918	531	2.50	1.76	22.9	9.3
2	10 " – 4 P. M.	57	265	3.00	2.05	1.7	5.4
4	$10\frac{1}{2}$ " – $2\frac{1}{2}$ "	1463	465	2.06	1.66	30.1	7.7
5	3 P. M.– 5 "	134	311	2.33	1.63	3.1	5.1
6	10 A. M.– 3 "	1070	1358	2.33	1.40	24.9	19.0
11	2 P. M – $4\frac{1}{2}$ "	385	111	2.00	1.53	7.7	1.7
12	$9\frac{1}{2}$ A. M.– 2 "	1160	129	2.00	1.36	23.2	1.8
		5187	3170			83.6	50.0

TABLE II. (CONTINUED.)

TREE NO. 12.

DATE OF COLLECTION.	DURATION OF COLLECTION.	GMS. SAP.		PER CENT SUGAR.		GMS. SUGAR.	
		OUTER.	INNER.	OUTER.	INNER.	OUTER.	INNER.
March 26				2.75	1.79		
27				4.30	2.03		
April 1	9 A. M.–11 A. M.			2.03	1.62		
2	10 " – 4 P. M.	778	1005	2.10	1.86	16.3	19.5
4	10½ " – 2 "	1942	1767	1.96	1.76	38.1	31.1
5	3 P. M.– 5 "	567	610	2.00	1.66	11.3	10.1
6	10 A. M.– 3 "	1879	2024	1.96	1.66	36.8	33.6
10	10 " – 5 "	595	617	1.83	1.76	10.9	10.9
11	10 " – 2 "	1696	2108	1.90	1.46	32.2	30.8
12	9½ " – 2 "	1385	2427	1.93	1.66	26.7	40.3
17	9½ " – 2 "		1905		1.83		34.9
18	9 " – 4 "		1746		1.83		32.0
19	9½ " – 1½ "		1697		1.76		29.8
20	8 " – 1½ "		790		1.80		14.2
22	8 " – 2½ "		395		1.46		5.8
		8842	17091			172.3	293.0

Number 10 was located about four rods from number 8, on the same side of the road and was about the same size and form. It was tapped by boring a hole with a five-eighths-inch bit to the depth of one inch and continuing it three inches deeper by the successive use of a half-inch, a three-eighths-inch,

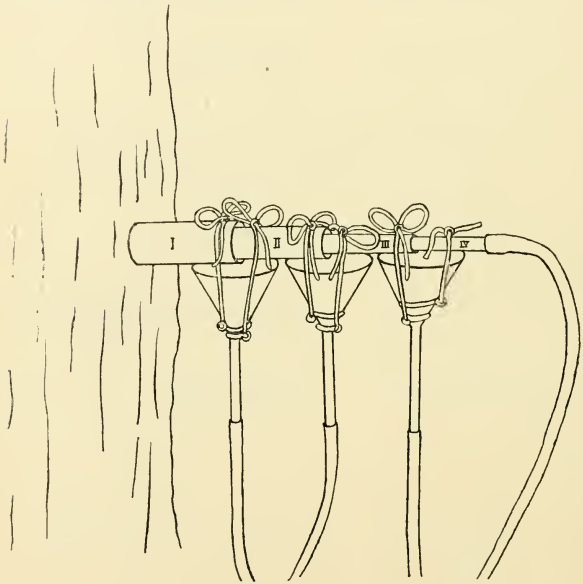


Fig. 2. Method of Collecting Sap.

and a one-fourth-inch bit. Four different sections of the hole were thus formed, and into each section was driven a tube of corresponding diameter.

These tubes fitted one within another, extending outside the tree to different lengths and were fitted with funnels and tubing as shown in Fig. 2.

The sections were designated as I, II, III and IV, beginning with the outer part. The sap was collected from the different spouts during the same length of time.

The innermost, section IV, never bled sufficiently to yield a sample for analysis, although the sap repeatedly stood in the end of the tube. This may have been due to the size of the hole but a one-fourth-inch hole will bleed freely as shown in Bulletin 24.

The relative variations in sap-flow from I, II and III were much alike until April 12, when the outer sections stopped bleeding and the flow from III reached the maximum.

In this respect number 10 yielded results very similar to number 12. In composition, however, it did not agree with the other two trees, but after the first two days, the inner portion yielded the richest sap.

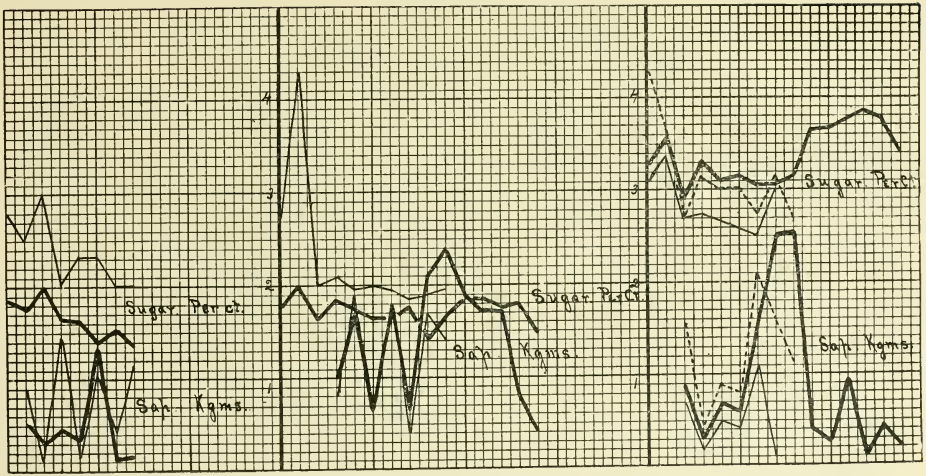
The buds burst and the leaves began to expand before the sap ceased to flow from section III.

TABLE III.

FLOW AND COMPOSITION OF SAP FROM DIFFERENT DEPTHS IN TREE No. 10.

DATE OF COLLECTION.	DURATION OF COLLECTION.	GRAMMES OF SAP.			PERCENTAGE OF SUGAR.			GRAMMES OF SUGAR.		
		I INCH.	II INCH.	III INCH.	I INCH.	II INCH.	III INCH.	I INCH.	II INCH.	III INCH.
March 26					3.14	4.33	3.29			
27					3.25	3.66	3.55			
April 1	9 A. M.–11 A. M.	717	1542	922	2.73	2.71	2.88	19.6	41.8	26.6
2	10 " – 4 P. M.	208	373	275	2.76	3.16	3.33	5.7	11.8	9.1
4	10½ " –12 M.	501	910	700	2.66	3.00	3.13	13.3	27.3	21.9
5	3 P. M.– 5 P. M.	424	811	601	2.58	3.00	3.16	10.9	24.3	19.0
6	10 A. M.– 3 "	1083	2106	1562	2.50	2.76	3.06	27.1	58.1	47.8
11	10 " – 4½ "	116	1604	2502	3.06	3.16	3.06	3.5	50.7	76.5
12	9½ " – 2 "		1165	2510		2.66	3.16		31.0	79.3
17	9½ " – 2½ "			449			3.63			16.3
18	9 " – 4 "			260			3.66			9.5
19	9½ " – 1½ "			934			3.76			35.1
20	8 " – 1½ "			131			3.86			5.0
22	8 " – 2½ "			411			3.76			15.4
24	9 " – 2 "			220			3.40			7.5
		3049	8511	11477				80.1	245.0	369.0

DIAGRAM II.



TREE NUMBER 5.

Outer part of Hole, _____

Inner part of Hole, ▬▬▬

TREE NUMBER 12.

TREE NUMBER 10.

I Inch, _____

II Inch, ...

III Inch, ▬▬▬

The results obtained in these studies upon the flow of sap are in accord with the observations of Professor Wood reported in Bulletin 24 and add force to his conclusion that more sap flows from a deep hole than from a shallow one. The exact depth to which the hole should be bored is unsettled and may prove to depend upon the size of the tree.

The longer flow of sap from the inner wood of numbers 10 and 12 agrees with the practice of retapping trees toward the close of the season.

The results obtained by studying the composition of the sap from different depths in the tree, are still contradictory, as was shown in Bulletin 25; inasmuch as two trees yielded the richer sap from the outer wood and one from the inner wood. The results, however, are in accord with the statement that the more sap there is produced by a tree, the greater is its yield of sugar.

The glucose (*reducing sugars*) and ash were determined several times in the samples from numbers 8 and 11, but the difficulties in the way, prevented a continuity of results. However, figures were obtained from samples distributed through the season and including the last ones. The sap contained such minute quantities of both substances that it was found necessary to evaporate a weighed quantity to a thin syrup, determine the glucose and ash in this and calculate back to the original.

Nine estimations of glucose were thus made in the case of each of the trees. The results from number 8 ranged from 0.0042 to 0.0097 per cent with an average of 0.0075 per cent.

Number 11 showed higher results, the range being from 0.0051 to 0.0244 per cent and the average 0.0123 per cent. The highest results were obtained in the early part of the season, instead of from the last runs.

Ten estimations of ash were made in the samples from number 8 and twelve in those from number 11. The range in the former was from 0.029 to 0.114 per cent and in the latter from 0.038 to 0.087 per cent. The average percentage was almost the same in both being 0.051 and 0.052 respectively.

The soil in this vicinity is a clay loam with clay subsoil and overlies granite ledges.

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